UNIVERSITY OF SASKATCHEWAN

DEPARTMENT OF COMPUTER SCIENCE

CMPT 250

Final Examination

3 hours Closed Book April 14, 2001

Marks

This exam is out of 150. Thus, you have 1 minute per mark with 30 minutes to spare. Use this in judging how much time to spend on a question.

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12 1. Consider the inheritance diagram and code given below. Note that routine p is initially defined in class D and then redefined in both A and B. For each of the instructions in the code, indicated whether (i) it fails to compile, (ii) it compiles but fails at run time, or (iii) it compiles and executes without generating an error. If it executes without error, briefly state what it does. For each instruction, assume that instructions above it that do not fail have been executed, and instructions above it that fail have been commented out.

```
Local a : A
       b : B
       d : D
do
       !!a.make
       a.r
       a.p
       d := a
       d.r
       d.s
       d.p
       d.q
       b := d
```

b ?= d

b.q

b.r

a := d

a ?= d

end

8 2. What is meant by coupling in the analysis of the quality of a software module? Should one attempt to design a system to have weak or strong coupling? Why? Give a design pattern to promote better coupling.

8 3. When searching a large collection of items, sometimes it is assumed that all items are equality likely, and sometimes some items are assumed to be much more likely. How does this affect the data structure selected to store the collection? In each case, what data structure would you choose and why?

5 4. For the binary tree given below, do a series of rotations that end up with a height balanced tree. Each rotation should be one of the valid rotations for a height balanced tree. Give the tree that is obtained after each rotation. As is obvious, the tree given below is not height-balanced.

20 5. Suppose that a class WT_BAL_TREE[G] has been defined by inheriting from LINKED_SIMPLE_TREE_UOS[G]. The WT_BAL_TREE class implements a weight-balanced tree. Each node has an INTEGER attribute called weight that stores the weight of the item stored in the node. Note that the WT_BAL_TREE class is properly defined and includes the features of a LINKED_SIMPLE_TREE_UOS[G] plus many others. You are to give the Eiffel code to define a descendant of WT_BAL_TREE. The descendant should have two new functions. One function will return the smallest weight in the tree. The other function will return the largest weight in the tree. Include any relevant preconditions and/or postconditions for your functions.

The main features of *LINKED_SIMPLE_TREE_UOS*[G] are:

Note that to shorten the description, LS_TREE[G] is used instead of *LINKED_SIMPLE_TREE_UOS*[G].

is_empty : BOOLEAN

is_full : BOOLEAN

out : STRING

make

initialize (lt:LS_TREE[G]; x:G; rt:LS_TREE[G])

root_left_subtree : LS_TREE[G]

root_right_subtree : LS_TREE[G]

root_item : G

8 6. There are three approaches to expresses an Abstract Data Type. For any two of them, explain how they express the semantics of a type, and explain how they differ.

14 7. Suppose that the items of a keyed dictionary are stored in a binary file.

i. Give the general algorithm for the search of a specific item

   a. when the file is a sequential file
   b. when the file is a direct file
   c. when the file is an indexed-sequential file

i. What is the most time consuming operation in such searches?

10 8. The real roots of a quadratic equation $ax^2 + bx + c - 0$ are given by the formula:

$$\boxed{\;x\;}$$

where $b^{2} 4ac$; a, b, and c are real values; and $a \ldots 0$. For this problem:

Identify appropriate valid and invalid equivalence classes for testing a routine to compute the roots. Formulate the test cases so as to cover as many equivalence classes as possible.

20 9. Given a connected undirected graph $G=(V,E)$ that represents a communications network. Suppose some links/edges are more reliable than others. Assume that the graph is

stored in an adjacency lists structure where each edge has an attribute reliable : BOOLEAN, that indicates whether the edge is more reliable or not. A reliable connection consists of a pair of vertices and a path between them where all edges on the path are reliable. A pair of vertices might not have a reliable connection, or might have many of them. The problem is as follows. You are given a pair of vertices which do not have a reliable connection. You are to use an approach based on either the breadth-first technique or the depth-first technique to determine the number of reliable connections added to the network if a reliable edge is created between the two vertices.

a. Give a general algorithm outlining your approach.
b. Give a detailed algorithm to solve the problem.

> For the graph below, where reliable edges are drawn with double lines, if edge (a,b) is made reliable, then 8 reliable connections are added to the network. If instead edge (c,d) is made reliable, then only 4 reliable connections are added.

a b

c d

10. The University of Saskatchewan's Development and Alumni Affairs (DAA) office oversees all fundraising and alumni activities. DAA plans and coordinates the University's fundraising activities and tracks both alumni (i.e., graduates of the U of S) and donors. The following business units are directly involved in activities related to development and alumni affairs:

- President's Office
- Controller's Office
- Registrar's Office

The President's Office provides overall direction and executive management to the University. For the purpose of DAA activities, the President serves as a representative of the University to external donors and prospective donors. The system is to provide to the President background information about donors, and the President's Office should be able to record contact information for donors.

The Controller's Office is comprised of Accounting Services and Payment Services. DAA reports financial information to Accounting Services, and Accounting Services provides DAA with account information. Payment Services does payroll for the University including the processing of donations to the University made by staff and faculty.

The Registrar's Office maintains academic records for the University. For the DAA, they provide biographical and degree information on graduating students .

The functionality required in the DAA system is as follows:

Person Tracking: Involves compilation and maintenance of biographic and demographic information relating to alumni. This involves:

- adding, editing, and deleting person records.
- tracking alumni clubs and club members in various cities.

Prospect Tracking: Involves identification of potential donors.

Pledge Processing: Recording and tracking pledges and planned gifts. This includes:

- adding, editing, and deleting pledge and planned giving records.
- generating pledge confirmations and pledge payment reminders.
- tracking and reporting pledge payment histories.
- exporting payroll deductions to the University Payroll System.

Income Processing: Encompasses all aspects of handling donations, incoming gift payments, pledge payments, planned gifts, and gifts-in-kind. This involves:

- adding, editing, and deleting payment records.
- generating charitable receipts for income tax purposes.
- identifying matching gifts.
- acknowledge payments.

You are to design an object-oriented software system for this problem.

The deliverables consist of the following:

7 a) A list of actors and use cases for this application.

18 b) Two sequence diagrams for:

o recording a pledge by a specific donor for $100 per month for a five year period.

o issuing a charitable receipt for a specific donor for a particular taxation year.

15 c) An overall (complete or composite) class diagram for your system, i.e., include all

classes and their associated relationships for your system.

5 d) Any inheritance diagrams with important attributes and routines.

Total 150 The end